

**Distribution, Abundance, and Status of American Eels in Three Headwater
Streams on the George Washington-Jefferson National Forest**



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Introduction

American eels (*Anguilla rostrata*) are found in watersheds of the Atlantic coast from southern Greenland to South America (Jenkins and Burkhead 1994). Since the mid-1970's, harvest pressures and habitat losses have led to declines in the abundance of American eels (ASMFC 2000). The Atlantic States Marine Fisheries Commission developed and approved the American Eel Fishery Management Plan to "improve the knowledge of eel habitat utilization at all life stages, to protect and enhance American eels in historic waters, to provide adequate forage for natural predators, as well as support ecosystem health and food chain structure" (ASMFC 2000).

Information on the distribution and abundance of American eels in headwater streams of Virginia is limited. Smogor et al. (1995) suggested that in Virginia the American eel declines in abundance, but individuals achieve a greater size with increasing distance from the ocean. On several occasions eels have been captured in the headwater streams of the George Washington-Jefferson National Forest (GWJNF) during electrofishing surveys that targeted other species of fish (Center for Aquatic Technology Transfer (CATT), unpublished data). Preliminary electrofishing surveys targeting American eels were performed on two headwater streams, Paddy Run in the Shenandoah River drainage and Shoe Creek in the James River drainage, during July 1999 in an effort to assess the status of American eel populations in GWJNF.

A total of five American eels were captured by electrofishing a 3.7 km reach of Paddy Run and 61 eels were captured in a 2 km reach of Shoe Creek. The eels were measured and implanted with Passive Integrated Transponder (PIT) tags. The size distribution of the eels tagged in Shoe Creek ranged from 174 - 775 mm, which suggested the presence of multiple age classes (C. Andrew Dolloff, Virginia Tech, personal communication). Although eels were known to inhabit Shoe Creek, eel abundance of this magnitude was unexpected.

A second electrofishing survey was performed on Shoe Creek in October of 1999 in an attempt to recapture eels marked during the July 1999 survey. The team only captured seven eels in the same 2 km reach without any recaptures. Possible explanations for the lack of recaptures and overall low number of eels included mortality after sampling, inability to capture eels in October, or that the eels emigrated from the reach. Sampling methods in October were identical to July and no mortality was observed during or immediately following sampling which suggested that the eels had moved out of the study reach. This unexpected disappearance generated considerable interest among both state and federal agencies. Agencies were concerned as to why the eels left and whether or not this was a natural occurrence. Based on the preliminary results, a comprehensive study was launched to investigate the seasonal distribution and relative abundance of American eels in Shoe Creek and other small headwater tributaries of the James River drainage.

P. A. Strickland, a graduate student at Virginia Polytechnic Institute and State University, in conjunction with CATT and GWJNF designed a study to investigate the daily movement, seasonal distribution, and habitat use of American eels in three headwater streams in the James River drainage. In addition, a lower intensity investigation of the eel population in Paddy Run was continued. The results of these studies will help determine distribution, abundance, habitat use, and restoration potential for the American eel in headwater mountain streams of Virginia. This information is needed for the protection of eel habitat and migration corridors as well as development of restoration plans for eels. The present report summarizes the results of work performed on the American eel projects during 2000.

Methods

Paddy Run

In an attempt to recapture eels marked in 1999, a second electrofishing survey was performed on Paddy Run in 2000. Paddy Run is a low gradient second order tributary of Cedar Creek in the Shenandoah River drainage. No habitat survey was performed on Paddy Run, however it was noted that the riparian area was forested and the stream was 4 – 6 m wide in the study reach. The 1999 and 2000 electrofishing surveys both started at the confluence of Cove Run and Paddy Run (in Vance's Cove). The 1999 survey ended 3.7 km upstream of the confluence. This reach included 1.0 km surveyed by the CATT and 2.7 km surveyed by GWJNF biologists. The 2000 survey ended 5.6 km upstream of the confluence of Cove Run and Paddy Run. One backpack electrofishing unit and two netters were used to make a single pass through the study reaches during both surveys. During the 2000 survey captured eels were weighed, measured, and checked for old marks and tags. The location of capture (stream meter) was recorded for each eel. Eels without marks or tags were injected with PIT tags and given a left pectoral fin clip.

Shoe Creek, South Fork Piney River, and South Fork Tye River

Study Sites

Daily movement, seasonal distribution, and habitat use of American eels were investigated on 2 km reaches in Shoe Creek, South Fork Piney River, and South Fork Tye River (Figure 1). South Fork Tye River and South Fork Piney River are second order tributaries of the Tye River in the James River Drainage. Shoe Creek is a second order tributary to South Fork Piney River. The riparian area of each stream is heavily forested and streamside houses are rare. No angling for American eels exists on any of the streams. Shoe Creek has a drainage area of approximately 11.7 km². The study reach has a maximum depth of 200 cm and stream width ranges from 3.5 - 14.5 m. The South Fork Piney River has a drainage area of approximately 13.0 km². The study reach has a maximum depth of 145 cm and stream width

ranges from 3.0 - 15.4 m. The South Fork Tye River has a drainage area of 33.6 km². The study reach has a maximum depth of 125 cm and stream width ranges from 1.5 - 14.5 m.

Fish Fauna

The fish fauna (other than American eels) of Shoe Creek, South Fork Piney River, and South Fork Tye River were characterized by electrofishing three 50 m reaches located within the 2 km study reach of each stream. Two backpack electrofishing units with one netter each were used to make a single pass through each of the 50 m reaches. A third netter followed the electrofishing units up the stream to capture fish that emerged behind the crews. All fish species captured were measured and weighed and the location of capture was recorded.

Instream Habitat

Instream habitat was characterized for the 2 km study reaches on Shoe Creek, South Fork Piney River, and South Fork Tye River by performing BVET habitat surveys (Dolloff et al. 1993) during June 2000. During the surveys the number and surface area of pools and riffles, water depth, substrate types, and counts of large woody debris were recorded. This information will be used in the final report to characterize habitat used by American eels during the radio telemetry study (see below).

American Eel Population Estimates

American eel mark-recapture studies were performed on Shoe Creek, South Fork Piney River, and South Fork Tye River during June and July 2000. Two backpack electrofishing units with one netter each were used to make a single pass through each mark-recapture reach. A third netter followed the electrofishing units up the stream to capture fish that emerged behind the crews. Eels were marked in a section that began 500 m upstream of the start and ended 500 m downstream of the end of the 2 km study reach on each stream. Each captured eel was measured, weighed, and marked with a pectoral fin clip. The location of capture was recorded and each eel was released at the point of capture. Recapture began the day after marking ended. The entire 2 km study reach was electrofished during recapture in an effort to assess the number of eels moving out of the marking area. Data from the mark-recapture studies will be used in the final project report to calculate American eel population sizes. In addition, most eels captured during the mark-recapture were injected with PIT tags to allow for an investigation of eel growth (see below). Small body size prevented several eels from being injected with PIT tags during the mark-recapture.

American Eel Growth

Several hundred eels were marked with PIT tags in the study reaches of Shoe Creek, South Fork Piney River, and South Fork Tye River during summer 2000, mostly during the mark-recapture studies (see above). PIT tags allow us to individually identify fish, which in turn allows us to calculate the growth rate of any eel that is marked with a PIT tag and is later recaptured. During 2000 we were able to recapture and measure 22 of 68 eels that were marked with PIT tags during the 1999 surveys. Recaptured eels appeared to be in good condition with no obvious signs of infection or trauma caused by the marking procedure. Eels marked in 2000 and recaptured in 2001 will allow for a more complete analysis of growth in the final project report.

American Eel Movement

Investigation of seasonal and diel movement of American eels using radio telemetry began in summer 2000. Eels captured by backpack electrofishing in Shoe Creek, South Fork Piney River, and South Fork Tye River were surgically implanted with radio transmitters weighing approximately 5 g. All eels were > 500 mm, 240 g and appeared to be in good condition following surgery. Seasonal movement was investigated by locating all individuals with radio transmitters once every 3–7 days. Diel movement was investigated by locating individual eels once every hour for 24-hour periods. Activity was also monitored during 24-hour periods by listening for fluctuations in signal strength (Clapp et al. 1990).

Results

Paddy Run

We electrofished a total of 5.6 km of Paddy Run in August 2000 (Table 1). This was approximately 1.9 km more than was electrofished in July 1999. No fish that were marked during the July 1999 survey were recaptured during August 2000. An additional five eels were captured and implanted with PIT tags in August 2000.

Shoe Creek, South Fork Piney River, and South Fork Tye River

Fish Fauna

Brook trout (*Salvelinus fontinalis*), blacknose dace (*Rhinichthys atratulus*), and torrent sucker (*Thoburnia rathbunae*) were the only species other than American eel captured within the 50 m reaches of Shoe Creek and South Fork Piney River (Table 2). Brook trout, blacknose dace, torrent sucker, bluehead chub (*Nocomis biguttatus*), longnose dace (*Rhinichthys cataractae*), mountain redbelly dace (*Phoxinus phoxinus*), and rosieside dace (*Clinostomus funduloides*) were captured in addition to American eel within the 50 m reaches of South Fork Tye River.

Instream Habitat

Instream habitat data was collected on the 2 km study reaches of each stream during June 2000. The habitat surveys were performed on 6/1, 6/14, and 6/15 on Shoe Creek, South Fork Piney River, and South Fork Tye River, respectively. The data will be paired with radio telemetry data to assess American eel habitat use in the final project report.

American Eel Population Estimates

Population estimates for the 2 km study reaches on each stream will be calculated from the data collected during the summer 2000 mark-recapture surveys (Table 3). Captured eel sizes ranged widely (Figure 2) and population estimates may be made individually for several different size classes (P. A. Strickland, pers. comm.). Population estimates will be made using the Chapman modification of the Peterson method (Ricker 1975).

American Eel Growth

A total of 22 eels marked with PIT tags in Shoe Creek during the 1999 surveys were recaptured at least one time in 2000 (Figure 3). Several of the recaptured eels were either not measured or weighed and could not be included in the analysis. The median increase in length and weight were 34 mm and 40 g, with ranges of 1 to 101 mm and 7 to 107 g. More than 400 additional eels in the three study streams were injected with PIT tags during summer 2000 (Table 4). These eels will be used to assess eel growth from 2000 – 2001.

American Eel Movement

A total of 22 eels were implanted with radio transmitters during summer 2000, ten in South Fork Tye River, ten in Shoe Creek, and two in South Fork Piney River (Table 5, Figure 4). Three eels have been lost since tracking began, two in Shoe Creek and one in South Fork Tye River. The transmitter of one of the eels in Shoe Creek was found on the stream bank. The other lost eels apparently moved too far downstream to be located. We unsuccessfully attempted to locate the eels by driving several miles downstream of the study areas. The battery life of the transmitters should permit us to continue tracking the remaining eels through at least fall of 2001. More eels in South Fork Piney River may be implanted in spring 2001.

Seasonal range sizes have ranged from zero to 6.8 km (Table 5, Figure 4). Seasonal range is defined here as the distance between the furthest upstream and the furthest downstream occupied habitat unit (pool or riffle). Most movements were made prior to winter. During the winter it appeared that eels

buried themselves in the stream substrate. Several appeared to be located near or under large boulders and undercut banks.

Several diel observations were also made during 2000 also. Preliminary evidence points to seasonal differences in diel activity patterns. During the summer the eels were most active for three to five hours immediately following sunset. During the fall the same eels were monitored but activity was much more sporadic, with more variability in activity between individuals. During the winter the eels displayed very little activity. More diel observations will be made during spring, summer, and fall of 2001.

Discussion

Information on the distribution and status and knowledge of habitat utilization and seasonal behavior of American eels in headwater streams is limited. This project seeks to assess the abundance, habitat use, growth, and daily and seasonal movements of American eels in headwater streams of Virginia. The work performed on the eel project in 2000 has begun to provide basic information that is necessary for the protection of eel habitat and the restoration of impacted eel populations.

Several interesting observations have already been made, including the apparent use of boulders and undercut banks as winter habitat. When we captured a much lower number of eels using electrofishing in Shoe Creek during fall than during spring we hypothesized that many eels had moved out of the smaller stream and into larger, deeper streams for the winter. However, radio telemetry results have shown that during the winter the majority of eels remained in the headwater streams but became less active, apparently occupying areas underneath boulders and undercut banks, which would decrease their vulnerability to capture by electrofishing. This seasonal change in behavior and habitat use has implications for the management of streams with eel populations. For example, high sediment loads could destroy winter habitat by filling the interstitial spaces and undercut banks that may be needed by eels during the winter. In addition, using electrofishing to estimate eel population abundance during the late fall and winter could result in large underestimates of population size. These preliminary results clearly warrant further investigation.

Data collection and analysis during 2001 will continue to provide information needed for the management of eel populations in headwater streams (Table 6). Radio telemetry data will be collected until the transmitter batteries expire, likely during fall/winter 2001. We will also attempt to recapture eels marked with PIT tags during 2000 to investigate growth of eels from 2000 – 2001. The final project report will provide a complete summary of all data collected during the eel study, including American eel population estimates, habitat use, growth, and movement in headwater streams of Virginia.

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Table 1. Location, size, and marks given to eels captured in Paddy Run in August 2000. Distance indicates meters upstream from confluence with Cove Run (Vance's Cove) . 'LP' indicates left pectoral fin clip. Other species captured in the section were blacknose dace, longnose dace, sculpin spp., fantail darter, rosieside dace, white sucker, creek chub, and brook trout. Brown and rainbow trout were only captured downstream of meter 3615. Location of young-of-year trout species captured is noted in 'Comments'.

Distance (m)	Total Length (mm)	Weight (g)	New or Recapture	Pit Tag	Clip	Comments
68.6	822	1023	New	423B7A5337	LP	
424.9						384 mm brown trout captured here
782.4						Concrete bridge with culvert
978.0						Small trib on left, <.5 m wide
1236.5						Side channel in on right
1264.2						Side channel out on right
1303.1						Small tributary on left, trickle
1475.0						Gabion (erosion control structure) on left bank
1481.4						Tributary on left, dry
1523.7						Small eel escaped capture
1700.0						Rainbow trout YOY here
1702.0						Tributary on right, low flow
1729.7						Tributary on right, fork of previous?
1814.5						Ford here
1842.0						Tributary on left
2803.6						Two braided side channels in on left
2855.3						Side channel out on left
2874.9						Trail crossing
2950.3	394	93	New	422E2B3D22	LP	Brook trout YOY here
3294.4						Trail crossing
3371.8	720	830	New	422E2E6161	LP	
3615.6						Stocked fish end here, YOY brook trout captured
3638.0						Tributary on right, dry
3850.3	638	493	New	422D4F173A	LP	
4245.3						Tributary on left, small
4278.9						Side channel in on right
4301.9						Side channel out on right
4337.5		469	New	423CD63E3C	LP	

Table 1. Continued.

Distance (m)	Total Length (mm)	Weight (g)	New or Recapture	Pit Tag	Clip	Comments
4615.0						Old road crossing
4832.0						Eroded bank on right
5128.7						Stream getting very small
5535.8						Old ford, trib on left
5631.4						Pools <12 cm deep, channel 1 m wide, trib on left

Table 2. Number and size of all species other than American eel captured by electrofishing in three 50 m sections of Shoe Creek (SC), South Fork Piney River (SFP), and South Fork Tye River (SFT). Species: BKT = brook trout, BND = blacknose dace, TS = torrent sucker, BHC = blue head chub, LND = longnose dace, MRB = mountain redbelly dace, RSD = rosyside dace.

Stream	Species	Section	Count	Length (mm)		Weight (g)	
				Min	Max	Min	Max
SC	BKT	1	81	63	213	1	65
		2	46	64	225	2	118
		3	69	66	240	3	146
	BND	1	86	36	85	1	5
		2	36	43	85	1	5
		3	51	49	95	1	33
	TS	1	22	69	121	2	19
		2	14	90	170	8	50
		3	7	60	129	2	22
SFP	BKT	1	56	46	174	1	62
		2	44	46	219	1	102
		3	69	41	190	1	86
	BND	1	28	42	84	1	6
		2	10	32	86	0	6
		3	58	35	66	1	2
	TS	1	2	78	152	6	44
		2	1	86	86	8	8
		3	0	0	0	0	0
SFT	BKT	1	76	54	193	1	78
		2	50	52	250	2	145
		3	73	65	251	4	142
	BND	1	19	51	90	1	6
		2	44	57	97	2	9
		3	26	45	84	1	6
	TS	1	25	39	152	1	43
		2	19	66	156	3	41
		3	15	80	168	5	58
	BHC	1	16	44	120	1	19
		2	6	53	112	2	15
		3	17	23	162	2	56
	LND	1	9	83	105	5	10
		2	10	86	132	5	21
		3	17	37	130	5	20
	MRB	1	53	39	72	1	2
		2	20	45	73	1	4
		3	15	50	63	1	22
	RSD	1	74	46	92	1	7
		2	51	56	90	2	7
		3	39	52	88	1	7

Table 3. Summary of 2000 mark-recapture data for South Fork Piney River (SFP), Shoe Creek (SC), and South Fork Tye River (SFT). Total eels captured indicates the number of eels captured during marking + unmarked eels captured during recapture.

Date	Stream	Marked	Recaptured	% Recaptured	Total Eels Captured
6/26 – 6/29	SFP	14	1	7	47
6/28 – 6/30	SC	44	8	18	98
7/5 – 7/6	SFT	105	23	22	301

Table 4. Number of eels marked (PIT Implants) with PIT tags during 2000 in South Fork Piney River (SFP), Shoe Creek (SC), South Fork Tye River (SFT), and Paddy Run (PR). PIT Recaps indicates the number of implanted eels that were recaptured at least one time during field activities in 2000.

Date	Stream	Activity	PIT Implants	PIT Recaps	% Recapped
6/26 – 6/29	SFP	Mark-Recap	38	1	3
6/28 – 6/30	SC	Mark-Recap	88	13	15
7/5 – 7-6	SFT	Mark-Recap	250	18	7
7/11/00	SFT	Transmitters	2	0	0
7/19/00	SFT	50 m sample	16	0	0
8/8/00	SC	Transmitters	16	1	6
8/9/00	PR	Mark-Recap	5	0	0
8/16/00	SC	Transmitters	7	0	0
9/29/00	SFP	Transmitters	2	0	0
Total	--	--	417	35	8

Table 5. Eels implanted with radio transmitters in South Fork Tye River (SFT), Shoe Creek (SC), and South Fork Piney River (SFP) during summer 2000. Status: transmitting = currently tracking eel, missing = cannot locate eel, bank = found transmitter on stream bank.

Transmitter #	Date Implanted	Days Tracked	Length (mm)	Weight (g)	PIT	Status	Range (m)	Stream
14	7/6/00	143	582	425	4238231C58	transmitting	71	SFT
34	7/6/00	143	520	242	422E4E1D4F	transmitting	73	SFT
56	7/6/00	143	580	453	422E3A093D	transmitting	462	SFT
76	7/6/00	143	607	408	423815790B	transmitting	607	SFT
93	7/6/00	143	620	474	422D6F3D5C	transmitting	6825	SFT
115	7/6/00	143	560	299	422E354D76	transmitting	90	SFT
134	7/6/00	143	628	520	42397C4355	transmitting	33	SFT
153	7/6/00	58	596	547	4238283A51	missing	2161	SFT
174	7/10/00	139	640	445	423C1E0131	transmitting	456	SFT
196	7/6/00	143	670	685	422E460C45	transmitting	2148	SFT
225	8/8/00	122	596	412	422E4D7423	transmitting	90	SC
244	8/8/00	122	620	431	407E517541	transmitting	51	SC
262	8/8/00	122	661	669	502E18712B	transmitting	7	SC
284	8/8/00	122	549	300	422E604E74	transmitting	2	SC
306	8/8/00	122	661	683	407E386F78	transmitting	2	SC
324	8/16/00	57	625	486	423C1D601B	bank	0	SC
344	8/16/00	114	551	282	423B1F6033	transmitting	25	SC
364	8/8/00	25	679	603	423A1B060F	missing	717	SC
385	8/16/00	114	596	441	407E4C5D27	transmitting	90	SC
404	9/29/00	114	521	271	422E4D5614	transmitting	9	SC
494	9/29/00	65	590	337	423B3F781C	transmitting	55	SFP
513	9/29/00	65	680	573	422E3A1608	transmitting	11	SFP

Table 6. Eel project activities planned for 2001.

Date	Activity Planned
February 2001	Telemetry – seasonal and diel movements
March – April 2001	Telemetry – seasonal movements
May – June 2001	Telemetry – seasonal and diel movements, Mark-Recapture - recapture electrofishing
July – November 2001	Data analysis and thesis/final report writing
December 2001	Present findings, turn in final project report

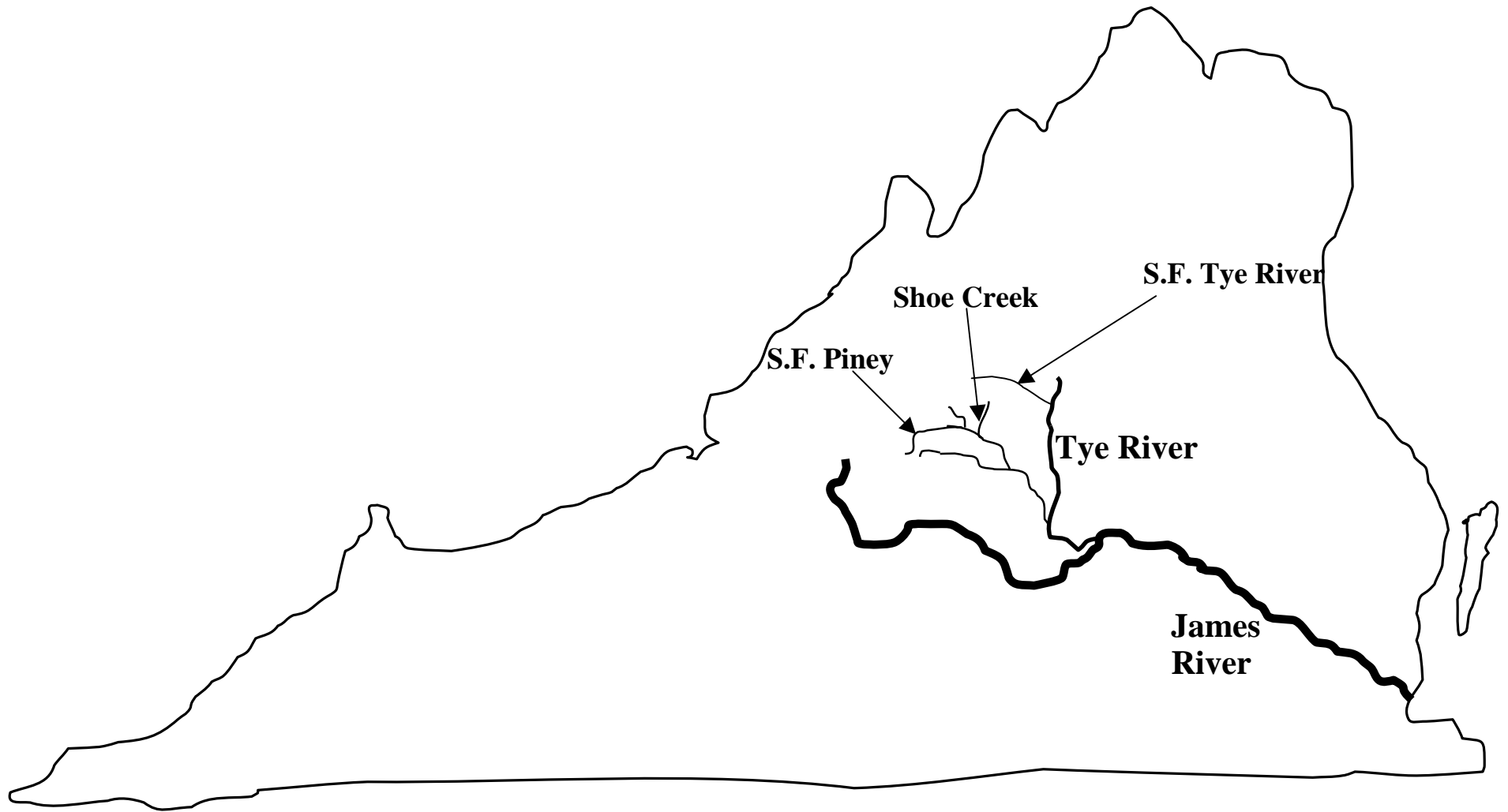


Figure 1. Location of eel study streams in the James River drainage. Map not drawn to scale.

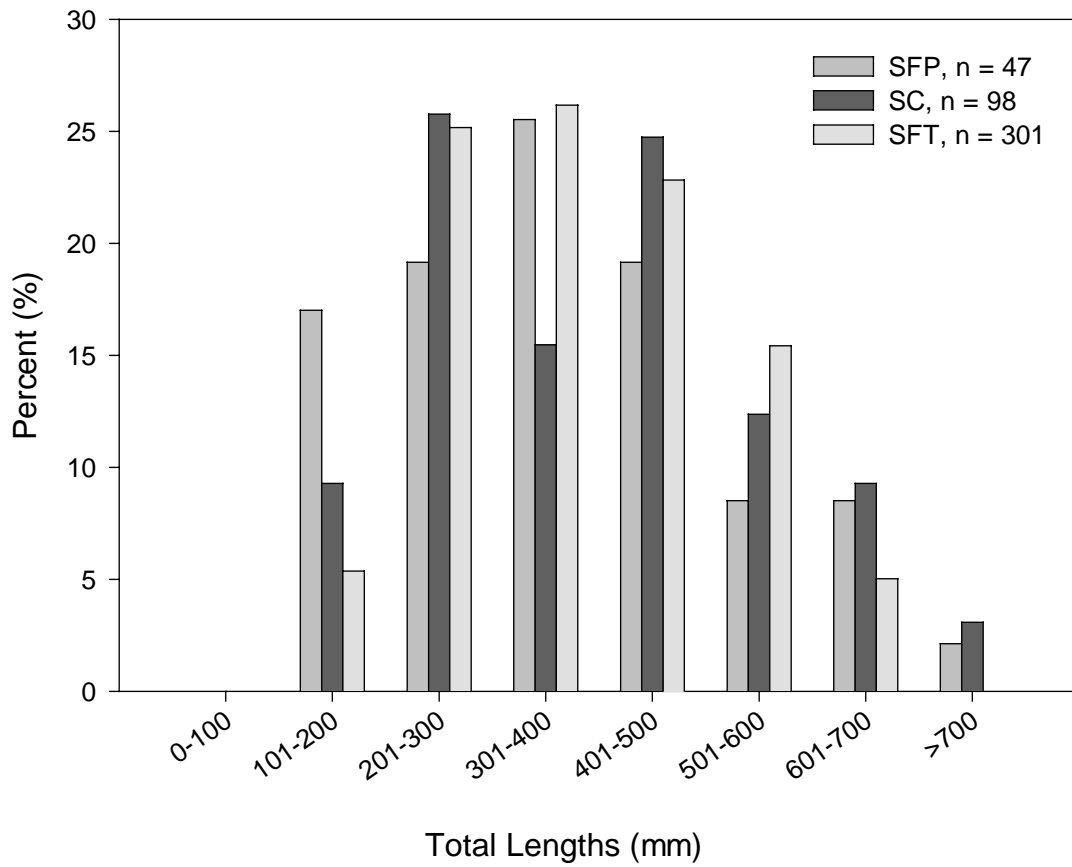


Figure 2. Length-frequency distribution of all American eels captured during mark-recapture electrofishing in South Fork Piney River (SFP), Shoe Creek (SC), and South Fork Tye River (SFT) during summer 2000.

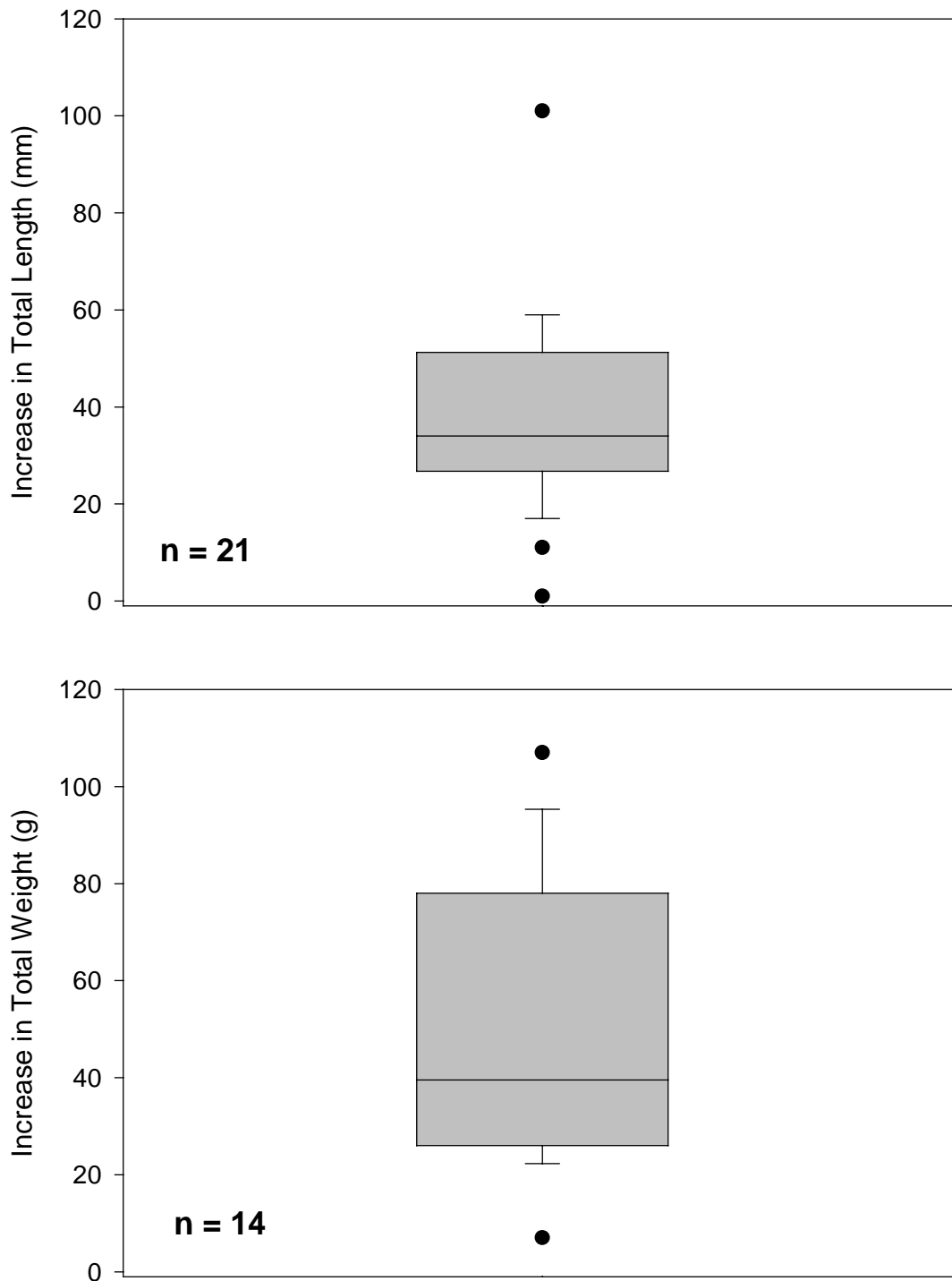


Figure 3. Increase in length (top) and weight (bottom) of American eels in Shoe Creek that were marked with PIT tags during 1999 and were recaptured in 2000. The line in the center of the box plot represents the median, the top and bottom of the box represent the 75th and 25th percentiles, the whiskers represent the 10th and 90th percentiles, and the closed circles represent the entire range of the data.

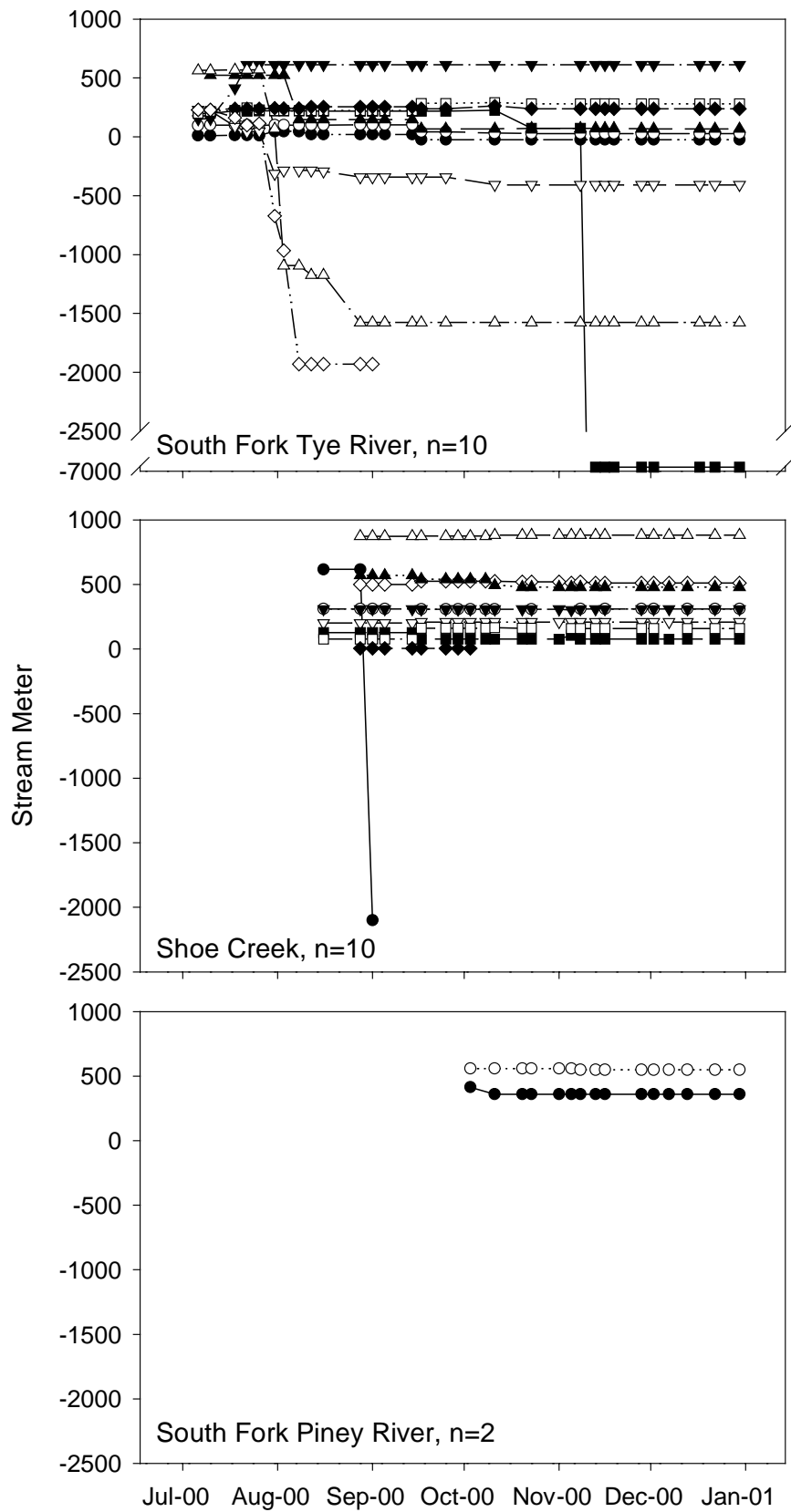


Figure 4. Range sizes of eels implanted with radio transmitters during 2000. Zero meters on the y-axis represents the furthest downstream point of the original study site on each stream. Movement downstream of this point is indicated by negative values.